LIV. *An Account of the great Benefit of blowing Showers of freſh Air up through diſtilling Liquors. By* Stephen Hales, *D.D. F.R.S.*

Read Dec. 18, 1755.

THE great importance of having a ſufficient ſupply of freſh water in ſhips has been the occaſion of many laudable attempts to make ſea-water freſh and wholſome: but all the attempts and diſcoveries hitherto made have laboured under this great and material objection, *viz.* the great quantity of fuel, that was neceſſary to diſtil, with a ſlow progreſs, a ſmall quantity of water, by any methods of diſtillation hitherto known. But I have lately happily, moſt unexpectedly, diſcovered an eaſy and effectual method to diſtil great quantities of water with little fuel; which I was led to by the following incidents; *viz.* Mr. Shipley, ſecretary of our Society *for the encouragement of arts, manufactures and commerce*, brought me acquainted with Mr. William Baily of Saliſbury-court, the author of many ingenious contrivances; who ſhewed me, in a ſmall model of a tin veſſel, a method, by which he has happily increaſed the force of the engine to raiſe water by fire, *viz.* by lifting up ſome of the boiling water, at every ſtroke, by means of a conical veſſel, with ſmall holes in it, full of tow; whereby the quantity of the aſcending ſteam or wreak was conſiderably increaſed. This led me to think, that a greater quantity of liquor might alſo by this means be diſtilled; but on trial I found the increaſe

increaſe to be only one twelfth part, though conſiderable in the expanded form of a ſteam. Hence I was led to try what would be the effect of cauſing an inceſſant ſhower of air to aſcend through the boiling liquor in a ſtill; and this, to my ſurprize, I found on trial to be very conſiderable. There was another circumſtance alſo, which probably conduced to lead my mind to this thought, *viz.* About ſix months before, Mr. Littlewood, a ſhipwright at Chatham, came thence purpoſely to communicate to me an ingenious contrivance of his, ſoon to ſweeten ſtinking water, by blowing a ſhower of freſh air through a tin pipe full of ſmall holes, laid at the bottom of the water. By this means, he told me, he had ſweetened the ſtinking bilge water in the well of ſome ſhips; and alſo a butt of ſtinking water in an hour, in the ſame manner as I blew up air thro' corn and gunpowder, as mentioned in the book on *Ventilators*.

2. The method, which I uſed to blow ſhowers of air up through the diſtilling water, was by means of a flat round tin box, ſix inches diameter, and an inch and half deep; which is placed at the bottom of the ſtill, on four knobs or feet half inch high, to make room for the liquor to ſpread over the whole bottom of the ſtill, that the heat of the fire may come at it. In larger ſtills this box muſt be proportionably larger, and have higher feet. And whereas the mouth of the ſtill is too narrow for the tin box to enter, which box ought to be within two inches as wide as the bottom of the ſtill; therefore the box may be divided into two parts, with a hinge at one edge or ſide, and a claſp at the other, to fix it toge-

ther, when in the ſtill. This box muſt be of copper for diſtilling ſea-water; mine was made of tin, for other liquors alſo. The air-pipe, which paſſes through the head of the ſtill, will help to keep the air-box from moving to and fro by the motion of the ſhip; or, if that ſhould not be found ſufficient, three or four ſmall ſtruts may be fixed to the ſides of the air-box. They muſt reach to the ſides of the ſtill. The cover and ſides of the air-box were punched full of very ſmall holes, one-fourth inch diſtant from each other, and about the twentieth part of an inch in diameter. On the middle of the cover or lid of this air-box, was fixed a noſil more than half inch wide, which was fitted to receive, to put on, and take off the lower end of a tin pipe, which was twenty inches long, and paſſed through a hole in the head of the ſtill: four inches of the upper end of this pipe were bent to a crook, almoſt at a right angle to the upright ſtem, in order thereby to unite the crook to the widened noſe of a pair of kitchen double bellows, by means of a ſhort leathern pipe of calves-ſkin. See PLATE X. *Fig.* 1. This tin air-box, and many more of them for other perſons, were made by Mr. Tedway, tinman, over-againſt the Meuſe-gate, Charing-croſs.

3. The double bellows were bound faſt to a frame, at the upper part of the iron noſe, and at the lower handle, in order the more commodiouſly to work them. And that the upper half of the double bellows may duly riſe and fall, in order to cauſe a conſtant ſtream of air (beſides the uſual contracting ſpiral ſprings withinſide), ſeveral flat weights of lead muſt be laid on the upper part of the bellows,

near

near the handle, with a hole in their middle, to fix them on an upright iron pin faſtened on the bellows; that by this means the weights may the more commodiouſly be put on or taken off. For, according to the different depths of the liquor in the ſtill, ſo will the force of the included air, againſt the upper board of the bellows, be more or leſs. Thus, ſuppoſing the depth of the water in the ſtill to be twelve inches, from the ſurface of the depreſſed water in the air-box, then the preſſure of the included air againſt the upper part of the bellows, will be equal to that of a body of water a foot deep, and as broad as the inner ſurface of that board. It will, therefore, be requiſite to add or take off weights, according to the different depths of the water in the ſtill, at different periods of the ſame diſtillation. The bellows muſt be proportionable to the ſize of the ſtill, but need not be very large. Where-ever the ſtills are fixed in ſhips, the air may be conveyed to them from the bellows, either through a ſmall leathern pipe, diſtended with ſpiral coiles of wire, or through Bamboo canes, or broad ſmall wooden pipes, like hollow fiſhing rods.

4. When I firſt diſtilled in this ventilating way, in order to eſtimate, what the difference might be in the quantity diſtilled, by that or the common method, I tried both ways, by receiving the diſtilled liquor into a quarter of a pint glaſs, eſtimating the times by a pendulum beating ſeconds. Where I found, to my ſurprize, that ſometimes three times more was diſtilled by ventilation than by the uſual way: But finding inequalities in the ſmall quantities thus diſtilled, in order the more fully and aſſuredly

to aſcertain the true proportion there was in the two methods of diſtilling, I put three gallons of water into the ſtill; and, when it boiled, put on the ſtill-head, and fixed its noſe to the worm-tub pipe; which tub was full of cold water. When it had diſtilled for an hour, the receiver was inſtantly taken away. And on meaſuring the diſtilled water, found it to be two quarts and 45 cubic inches by a glaſs divided into cubic inches. And a gallon containing 282 cubic or ſolid inches, this quantity of diſtilled water, which was 186 cubic inches, is $\frac{2}{3}$th part of a gallon.

5. Then, filling the ſtill as full of water as before, and when it began to boil, fixing the head to the ſtill and worm-tub, which was full of cold water; there was diſtilled in an hour, with conſtantly blowing ſhowers of freſh air up through the ſtilling liquors, five quarts, leſs by ſeven cubic inches, which is 345.5ths cubic inches; that is, little leſs than the double of the quantity, that is diſtilled in the uſual way. In ſeveral other diſtillations of a quart at a time, I found the quantity diſtilled by ventilation to be more than the double of that in the uſual way. So that the quantity by ventilation may, at a medium, be eſtimated the double of the uſual diſtillation. It is the well known property of moving air, to carry along with it a conſiderable quantity of adjoining vapour, as alſo of falling water to carry much air down along with it.

6. It is to be hoped therefore, that ſo conſiderable an increaſe in the quantity diſtilled will be of great benefit to navigation, as it may be done in leſs time, and with leſs fuel.

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7. In the account of Mr. Appleby's proceſs, for making ſea-water freſh, which is publiſhed by order of the lords of the admiralty, in the Gazette of Jan. 22, 1754, it is ſaid, that a ſtill, which contains 20 gallons of water, will diſtil 60 gallons in ten hours, with little more than one buſhel of coals; and therefore 120 gallons in 20 hours, with little more than two buſhels of coals. And by ventilation 240 gallons, or a tun; and 24 gallons may be diſtilled in twenty hours, making an allowance for the times of heating thoſe ſtills full of cold water; and a ſtill ſomething larger and wider will diſtil a tun in 24 hours; which will more than ſuffice for a ſixty gun ſhip, with 400 men, whoſe proviſion of water for four months is about 110 Tuns. And larger ſhips may either have proportionably larger ſtills, or elſe two of them. As for merchant-ſhips with few men, a ſmall ſtill will be ſufficient.

8. The ſecond-ſized ſtills contain 10 gallons, and will produce 60 gallons in 20 hours, with half the above-mentioned fuel; and by ventilation 120 gallons.

9. The leaſt ſtills contain five gallons, and will produce 32 gallons in 20 hours; and by ventilation 64 gallons in 20 hours.

10. I have ſeen ſome of theſe ſtills at Meſſrs. Steel and Stephens's, over-againſt Mercers-chapel, in Cheapſide, which have been made for this purpoſe. There are holes in the feet of the iron frame or ſtove, to ſcrew them down to the deck. They were fixed at the fore-caſtle before the maſt, in King Charles the ſecond's time, when they thought they had diſcovered the way to diſtil ſea-water, free from the noxi-

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ous ſpirit of ſalt, and from the nauſeous bitter taſte. Or, if it be thought proper, one part of the ſhip's boiler may be made uſe of, by adapting a ſtill-head to it.

11. Now ſuppoſing a ſtill to contain 25 gallons, and that four parts in five of it, *viz.* 20 gallons are diſtilled off: then, in order to diſtil a tun, or 210 gallons, the ſtill muſt be emptied, cleanſed, and refilled eleven times; and if the whole be done in 24 hours, full 16 of thoſe hours will be taken up in diſtilling at the rate of a gallon in about four minutes and an half; and the remaining eight hours of the 24, being divided into 11 equal parts, they will be each near 44 minutes to empty and cleanſe the ſtill, to refill it, and give the ſea-water a proper boiling diſtilling heat: whether this can be done in ſo ſhort a time, muſt be known by experience, and ought therefore firſt to be tried at land.

12. Doctor Butler, in his lately publiſhed method of *procuring freſh water at ſea*, propoſes the pouring in more ſea-water into the ſtill, thro' a funnel fixed in a ſmall hole in the head or upper part of the ſtill, when more than half the former water is diſtilled off; by which means the water in the ſtill will ſoon acquire a diſtilling heat; and this to be repeated ſeveral times; but then it will be requiſite to add each time more chalk, in ſuch proportion as ſhall be found requiſite. It will be well to try this method in hopes thereby to increaſe the quantity of water that is diſtilled. The hole in the head, or upper part of the ſtill, is to be ſtopped with a ſmall plate of copper, ſo fixed as to turn to and from over the hole.

13. Doctor

13. Doctor Butler uſed capital ſoap-lees, in the proportion of a wine quart to 15 gallons of ſea-water, which ſufficed for four or five times repeated pourings-in of more ſea-water into the ſtill. But as I have found, that a ſmall quantity of chalk has the ſame good effect, and is cheaper, and more eaſily to be had, it is therefore preferable to ſoap-lees.

14. When there is a fire in the cook-room, the ſea-water might be ready heated to put into the ſtill, without any additional expence of fuel, in the following manner, which I ſhall here deſcribe; tho' I think it probable that it will not be put in practice; yet, as farther improvements may poſſibly hereafter be made in it, and as it may be of uſe in ſome caſes, at land at leaſt, I ſhall here give an account of it, *viz.*

15. About the year 1718, Mr. Schmetou, a German gentleman, got a patent here for heating great quantities of water, with little expence of fuel, which he then ſhewed me. Having fixed a ſpiral iron worm-pipe, in ſuch a brick ſtove or chimney as women heat their irons in, thereby cauſing the water to run from a veſſel, through the worm-pipe, ſeveral feet length round, in the fire. About thirty years after I acquainted Mr. Cramond of Twickenham with this, as hoping it might be of benefit in diſtilling ſea-water. Upon which he procured ſuch a ſpiral iron worm-pipe, which was about twenty feet long, and ſix-tenths inch diameter; the diameter of the ſpiral coile was about fourteen inches.

16. This I fixed in a brick ſtove in my garden, with its upper end fixed to a veſſel, which contained 45 gallons of water. I found the event of this firſt

trial

trial to be as follows, *viz.* When the water run full bore, at the rate of a gallon in 17 ſeconds, the heat of the water was found, by a mercurial thermometer held in the ſtream, at the lower end of the pipe, to be 80 degrees above the freezing point, 180 degrees being the heat of boiling water. When, by means of a turn-cock, a gallon of water was two minutes in running, then the heat was 140. At which rate the 45 gallons would be an hour and half in running through the iron pipe; at which rate 25 gallons will run through in 50 minutes, with ſo conſiderable a degree of heat; and if it was an hour running, the heat would approach ſtill nearer to a boiling heat, when firſt put into the ſtill, which would forward the diſtillation, if wanted.

17. I pumped the heated water up again into the upper veſſel; and thus continued to circulate the heating water, till its heat was 160 degrees in the upper veſſel, *viz.* within 20 degrees, or one-ninth of boiling, the heat requiſite for plentiful diſtillation. I was in hopes that if the water in the upper veſſel could have been brought to a due degree of heat, and a ſtill-head were fixed on it, with its cooling worm-tub, then water might have been diſtilled in ſhips, by having the iron worm-pipe fixed in the chimney of the cook-room: But I found, that when the heat of the water in the upper veſſel was 160 degrees, *viz.* within one-ninth of boiling; then, in running through the iron worm-pipe again, it was ſo over-heated as to expand in the pipe, into an exploſive vapour, which hindered the running of the water. However I thought it not improper to give an account of this attempt, notwithſtanding it failed.

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not knowing whether this method of heating water may not in ſome caſes, at land at leaſt, be of uſe, thereby to ſave, in ſome degree, both fuel and time: Perhaps an iron worm-pipe of a larger bore might do better.

18. The waſte of fuel will be leſs in proportion to the quantity diſtilled in large, than in ſmall ſtills; and the wider the ſtill-head is, ſo much the more liquor will be diſtilled, and more with a worm-tub than without it. The worm-tub may be ſo covered as to prevent the flowing over of the water by the motion of the ſhip.

19. It is of great importance to take care to keep all parts of the ſtill clean, that there may be no ruſt or verdigreaſe in the copper, which will occaſion vomiting.

20. If it be neceſſary, the better to cloſe the joining of the ſtill head, it may be done with a lute or paſte, made of a mixture of powdered chalk and meal, wetted with ſalt-water.

21. Now that ſeveral effectual means are diſcovered, to make diſtilled ſea-water wholeſome, and alſo to diſtil it in much greater quantity in the ſame ſtill, in the ſame time, and with nearly the ſame quantity of fuel; it is reaſonable to believe, that it will be of great benefit to navigation, not only in ſaving much ſtowage room, for other important purpoſes; but alſo in procuring freſh ſweet wholeſome water, inſtead of ſtinking putrid water, hitherto uſed; which muſt needs have a tendency to promote that putrid diſtemper, the ſcurvy. And if withal due care be taken to exchange for freſh air the putrid cloſe confined air of ſhips, which has occaſioned the

death of millions of mankind; then navigation will become remarkably more healthy, and with little more danger to health and life than at land, except from ſtorms.

22. Now ſuppoſing, that, in a ſixty gun ſhip, the 110 tuns of water, for four months uſe, were diſtilled at the expence of three buſhels of coals to a tun, this would conſume nine chaldrons of coals: And as a chaldron of coals weighs about a tun and half; hence it appears, that coals will diſtil about eight times their quantity of water. And the 110 tuns of water weighing (at the rate of 2240 pounds to the tun) 138 tuns; and the nine chaldrons of coals weighing thirteen tuns and half, that is 94 tuns and half leſs than the 110 tuns of ſtore water; and allowing twenty-four tuns and half for the ſtill, water-caſks, and coals, there will be 70 tuns weight of ſtowage ſaved thereby, for other uſes. Or if ſome tuns of ſtore-water are carried by way of precaution, which it will be adviſeable to do, eſpecially at firſt, till they can be aſſured, by repeated experience, what quantity can be depended upon by diſtillation; even then about half the tunnage will be ſaved, which will be a very material advantage.

23. Though when the diſtilling liquor runs from the bottom of the worm-pipe, through a long pipe fixed to it, the waſte by the ventilating ruſhing air is not great, when the water in the worm-tub is not hot; yet the following precaution, if needful, may be uſed, in diſtilling by ventilation, *viz.* to fix at the lower end of the worm-pipe, by means of a wooden faucet, a ſmall caſk for a receiver; the faucet to enter the upper ſide of the head of the caſk, and

and in order to give a free paſſage for the great quantity of ventilating air to paſs off, and withal, at the ſame time to prevent the eſcaping of much moiſt vapour with it, it will be proper to fix at the bung-hole a long upright pipe of wood, or of any metal. I uſed a gun-barrel four feet and a half long; thro' which ſome ſmall degree of moiſt vapour eſcaped; as appeared by the dampneſs of a piece of paper, fixed at a little diſtance above the mouth of the gun-barrel. This vapour became viſible, and much increaſed, when the water in the worm-tub was very hot; at which time, leſs is diſtilled into the caſk-receiver; then alſo there is more danger of the ſpirit of ſalt ariſing. And it was obſervable, that the water in the worm-pipe veſſel heated much ſooner by ventilation than in the common way of diſtilling. For which reaſon that water ought to be changed ſo much the oftener, which can eaſily be done at ſea. The cocks alſo at the ſide of the worm-tub ought to be large, in order to let the hot water off the faſter.

24. But though the water in the worm-tub was ſooner heated by ventilation, becauſe a double quantity of hot ſteam paſſed through it more than paſſed through it in equal times in the common way of diſtilling; yet in the uſual way of diſtillation the liquor in the ſtill is hotter, with equal fire, as is evident by its aptneſs to boil over through the worm-pipe; whereas in the ventilating way it did not boil over, notwithſtanding a very hot fire was purpoſely made for a trial. The continual ſtreams of aſcending freſh air, not only in ſome degree abating the heat of the water, but alſo inceſſantly carrying off the more rarefied particles of the water, which, when expanded into a repelling ſtate,

do thereby cauſe the overflowing ebullition of the water. On which account it is probable, that leſs ſpirit of ſalt is formed and raiſed by ventilation than without it. As alſo on account of the freſh air aſcending, not from the bottom of the ſtill, where is the greateſt plenty of ſalt, eſpecially towards the latter end of each diſtillation; but about three inches from the bottom, *viz.* principally from the many holes at the ſurface of the air-box.

25. And whereas the quantity raiſed from the ſtill, and diſtilled into the caſk-receiver, cannot be ſeen; the proper quantity to be diſtilled in each diſtillation may with great accuracy be known, by having a well-cloſed pewter bottle, of the ſize of about half a pint, with a braſs wire as big as a gooſe quill, fixed to it, the wire to paſs through the receiver-caſk, near the bung-hole, which the floating pewter bottle will raiſe up, till the marks on the wire appear juſt above the caſk. I made uſe of a glaſs phial for this purpoſe. This wire will riſe and fall freely, notwithſtanding the motion of the ſhip, if it paſſes not only through the wood of the caſk, but alſo through a metalline pipe two or three inches long, fixed in that hole. And it will be known by the ſimmering or boiling noiſe of the water in the ſtill, whether it is hot enough to diſtil; for the running of the water into the receiver-caſk cannot be ſeen.

26. As it might be ſuſpected, that more ſpirit of ſalt would be raiſed, and diſtilled over in the ventilating way, than without it; having procured 18 gallons of ſea-water by the Margate hoy, which was taken up at ſome diſtance from the ſhore, I put three gallons

gallons of this ſea-water, as ſoon as I had received it, into the ſtill; and when it began to diſtil, air was blown up through it. For ſome time, as is uſual, in the diſtillation of ſea-water, no ſpirit of ſalt aroſe; but after diſtilling ſome time longer, there were very weak whitiſh clouds, with drops of ſolution of ſilver in aqua-fortis, as in the common way of diſtilling. Hence we ſee, that ventilation does not increaſe the quantity of ſalt, but rather probably ſomewhat decreaſes it, for the reaſons given, N° 24.

27. I diſtilled three gallons of ſea-water, which had ſtunk, and became ſweet again; when about ten quarts of it had been diſtilled off, then there began to be very weak whitiſh clouds with ſolution of ſilver, but none with ſolution of mercury; which ſhews the water to be hitherto good, agreeably to what I formerly had found to be the good effect of diſtilling ſea-water, which had putrified, and become ſweet again; of which I publiſhed an account in the year 1739. But when I continued the diſtillation on, a quarter of an hour longer, *viz.* till there was but a pint of water remaining in the ſtill, and the ſalts were incruſted on its ſides, up near three inches from the bottom, and lay in heaps at the bottom of the ſtill, then the diſtilled liquor had whitiſh clouds in it, with the ſolution of mercury in aqua-fortis. From this diſtillation we ſee, that putrefaction, by diſſolving the bittern ſalt and bitumen, into very minute parts, qualified them to combine with the more fixed common ſalt, ſo as to detain them from riſing in diſtillation.

28. I diſtilled three gallons of ſea-water, with the proportion of ſix ounces of Mr. Appleby's lapis infernalis,

fernalis, and ſix ounces of calcined bones to twenty gallons of ſea-water, as he directs. This water lathered well with ſoap, and boiled peas well.

29. I diſtilled alſo ſome ſea-water with half an ounce of ſtone-lime to a gallon, from the Clee hills in Herefordſhire, which having been preſerved ten months in a firkin, had ſlacked to dry powder. This diſtilled water did alſo lather well with ſoap, and boiled peas well; which proves that the lime, which is a fixed body, does not diſtil over with the water. Since I made this diſtillation, General Oglethorpe informed me, that his father, Sir Theophilus, told him, that lime was one of the ingredients, which he and the reſt of the patentees, in Charles the ſecond's time, called the cement, with which they made diſtilled ſea-water wholſome.

30. I diſtilled alſo ſome ſea-water with the like proportion of powdered chalk, which boiled peas well, and was better taſted than the waters diſtilled with lapis infernalis, or lime. I diſtilled alſo ſome ſea-water with an ounce of chalk to a gallon, but found no difference in the taſte of this, and that which had but half an ounce of chalk to a gallon: So that half an ounce of chalk to a gallon of water will be ſufficient; but where the ſea-water is ſalter, or more bituminous, more chalk may be added if needful.

31. Dr. Alſton, of Edinburgh, in the preface to the ſecond edition of his *Diſſertation on Quick-lime and Lime-water*, ſays, That "the like effect was "found in diſtilling ſea-water with lime, that it "neither precipitated a ſolution of ſilver in aqua-"fortis, nor a ſolution of corroſive ſublimate in wa-

"ter,

" ter, nor did it form a pellicle of various colours " on its ſurface, as did the water diſtilled by Mr. " Appleby's proceſs". And I find, page 35, of my book on this ſubject, that lime of oyſter-ſhells had the ſame good effect, but required two diſtillations; I might then uſe too ſmall a quantity of that lime. Hence it is probable, that the chalk, the lime, the lime in the lapis infernalis, and the lime in Dr. Butler's ſoap-lees, ſeize on and fix not only the bittern ſalt, but alſo the bitumen of the ſea-water, as we learn from the like effect in the purification of the ſalt of hartſhorn. That the ſaline ſpirit ariſes chiefly from the bittern ſalt, and not from the more perfect ſea-ſalt, is probable from hence, *viz.* When I diſtilled three gallons of common water, made as ſalt as ſea-water with common ſalt; no ſpirit of ſalt aroſe, even though the diſtillation was carried ſo far as to leave the ſalt, though very damp, to lie in heaps, and it was incruſted on the ſides of the ſtill, for about three inches from the bottom.

32. It is a conſiderable further advantage, that water thus diſtilled by ventilation, being thereby replete and freſhened with air, has for preſent uſe a more agreeable taſte than water diſtilled without ventilation, which requires the ſtanding a longer time to have its more diſagreeable aduſt taſte go off. And as the volatile oil of pepper-mint does ariſe on the wings of the ventilating air during the diſtillation; ſo alſo may that part of the bitumen, which is volatilized by heat; as alſo the volatile urinous ſalts of the ſea-water, which ariſe from animal ſubſtances, be ſublimed in the ſame manner.

33. It was obſervable, that the water diſtilled faſt, even though the water in the ſtill was below the ſurface of the tin air-box, through which the greateſt part of the aſcending ſhower of air ruſhed. Hence the ventilating air, in aſcending among the vapours, carries them off faſt. Hence it is to be ſuſpected, that this method of ventilation will not do well for ſimple waters, or fermented vinous ſpirits; becauſe they being very volatile, much of them may be carried off in waſte.

34. It was obſervable, that in theſe diſtillations of ſea-water, no whitiſh clouds appeared on dropping in ſolution of corroſive mercury, not even when conſiderably more than four parts in five of the water had been diſtilled over. And it was the ſame with the mixture of lapis infernalis, lime, and chalk; whence it is probable, that the lime and chalk ſeize on and fix the more volatile bittern ſalt, as does alſo the lime in the lapis infernalis. And it is well known, that ſugar, that ſweet ſalt, cannot be made without lime, on which, as its centre of union, it fixes and granulates.

35. And whereas with a ſolution of ſilver in aqua-fortis, which was much weakened and diluted with water, there appeared a faint degree of whitiſh cloud, in all the above-mentioned diſtillations, though not with the ſtronger ſolution of mercury, till the diſtillation was carried on, much beyond four parts in five of the water in the ſtill; when both ſolutions cauſed remarkably white clouds, eſpecially the ſolution of mercury; which indicates the quantity of the ſpirit of ſalt which was raiſed during the former part of the diſtillation to be exceeding ſmall, ſince it could

not

not ſeize on, nor diſengage the aqua-fortis from the ſtronger ſolution of mercury, though it did in a very ſmall degree in the weak ſolution of ſilver, ſo as to let looſe a very little of the ſilver, which thereby cauſed the faint clouds. When a drop of the ſolution of mercury was dropped into the diſtilled water, after a drop of the ſolution of ſilver, it reſorbed the ſilver cloud, and made the water clear, by means of the great proportion of acid aqua-fortis that was in it.

36. Now in order to make ſome eſtimate of the very ſmall quantity of ſpirit of ſalt in theſe ſeveral diſtilled waters, I dropped a drop of the ſolution of ſilver into an ounce, or 480 grains of pure rain water, which gave no clouds; but on dropping in a drop of ſea-water, which weighed a grain, the white clouds were ſtrong. And ſince ſea-water can diſſolve nine times more ſalt than it has in it; therefore, ſuppoſing the drop to be ſo fully impregnated with ſalt, then the ſalt would be the 480th part of the ounce of water. But as there is nine times leſs ſalt, therefore the proportion of the quantity of ſpirit of ſalt will be but the 4320th part. And how much leſs muſt be the proportion of ſalt in theſe diſtilled waters, which is not ſufficient to make a ſenſible impreſſion on ſolution of mercury, and but a faint one on much diluted ſolution of ſilver? Such diſtilled ſea-water will not therefore probably be unwholſome; almoſt all ſpring-waters have ſome degree of ſalt in them: But if there were more of the ſpirit of ſalt, a very ſmall quantity of pot-aſh, or pearl-aſhes, or ſalt of tartar, combined with it, will turn it into common ſalt, the quantity of which would be extremely little.

37. It may be well to be provided in ſhips with ſome ſilver diſſolved in aqua-fortis, mixed with pure rain-water, or diſtilled freſh water, in the proportion of ſixty drops to an ounce of the water: though it is probable it may ſeldom be wanted, unleſs in ſome doubtful caſes, when the taſte may not be accurate enough to perceive, whether there be any ſpirit of ſalt in the diſtilled water.

38. Since double the uſual quantity of vapour may by way of ventilation be carried off, common ſalt may thus be made much ſooner, cheaper, and better; becauſe, as there is much leſs fire uſed, ſo proportionably, leſs of the fine acid ſpirit of the ſalt, in which its virtue conſiſts, will be evaporated away: For it is well known, that the ſalt is beſt, which has undergone the leaſt action of fire in making.

39. This more ſpeedy method of evaporating will alſo be uſeful, in making many other evaporations; as in making pot-aſh, *&c.*

40. But ſome are apprehenſive, that this great improvement in diſtilling may be of ill conſequence in making thoſe deſtructive ſpirits cheaper, which are already but too cheap. Had not the improvement been of great benefit to mankind in many other reſpects, I ſhould have been far, very far, from endeavouring after it, or diſcovering it. But ſhould the event be to make thoſe ſpirits cheaper, and conſequently, by ſpreading farther, more deſtructive, the conſequence of that will be, that the increaſed raging devaſtation will the ſooner neceſſarily rouſe the nations to put a ſtop to what muſt be done hereafter: for if the ravages continue increaſing, as they have done for ſixty years paſt, the human

man ſpecies muſt needs not only be greatly debaſed, but even in great meaſure diminiſhed and deſtroyed. And yet none of the nations, whoſe very vitals are thereby conſuming and deſtroying, endeavour to put any ſtop to it, except the heads of the native Indians in North-America, who have long repeatedly intreated the Engliſh to ſell them no rum; which is as effectually extirpating of them, as the hornet did the unſubdued remainder of the Canaanites.

41. If mankind, inſtead of receiving and entertaining this peſt with almoſt univerſal applauſe and approbation, could prevail with themſelves to be in earneſt, to uſe means to deliver themſelves from it, then much might be done towards it, by lowering and weakening all kind of fermented diſtilled ſpirits with water, to a ſalutary degree, as is now practiſed in our plantations in America, in making punch ſo weak, as not to be hurtful; which, when it was much ſtronger, was well known to deſtroy multitudes. And where the like humane, wiſe, and laudable practice has been uſed in ſhips, it has had the ſame happy ſalutary effect.

42. What neceſſity or even temptation can there be to be averſe to the making them wholſome, inſtead of being venomous and deſtructive? and that not only of the lives, but even of the morals of mankind. How much therefore does it behove all, who have any concern for the honour and dignity of their own kindred ſpecies, any indignation at its being thus debaſed and diſgraced, any bowels of pity for the vaſt multitudes, not leſs than a million, that are yearly deſtroyed all over the world, by this moral as well as natural, and therefore worſt of all evils

that ever befel unhappy man, to uſe their utmoſt endeavours to deliver mankind from this peſt? But notwithſtanding this aſtoniſhing ravage and deſtruction of the human ſpecies, yet the unhappy unrelenting nations of the world ſeem as unconcerned about it, as if only ſo many thouſands, nay, millions of caterpillers or locuſts were deſtroyed thereby. Was there ever a more important occaſion to rouſe the indignation of mankind? Can we be calm and undiſturbed, when this mighty deſtroyer rears up its invenomed head every-where? The moſt zealous advocates for drams, even the unhappy beſotted dramiſts themſelves, the prolonging of whoſe lives, and whoſe real welfare both here and hereafter is hereby ſincerely intended, cannot find fault with this well-meant remonſtrance, in defence of them, and of all mankind, againſt this mighty deſtroyer, from one, who has long been labouring, and that not without ſucceſs, in finding means to preſerve multitudes of lives, by various ways.

LV. *An Account of the great Benefit of Ventilators in many Inſtances, in preſerving the Health and Lives of People, in Slave and other Tranſport Ships.* *By* Stephen Hales, *D. D. F. R. S.*

Read Dec. 18, 1755.

43. IT is to be hoped, that the ſeveral means here propoſed for having freſh and ſweet water at ſea, will be of great benefit in preſerving the health and lives of multitudes of that valuable